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SEMIKINETIC MODELING AND OBSERVATIONS OF HIGH-LATITUDE PLASMA OUTFLOW

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During this period we revised and had accepted by the *Journal of Geophysical Research* a paper[Ho et al.,1993a] in which we compare the expansion into near–vacuum and the evolution of density perturbations, in the form of altitude-localized density cavities and enhancements, in the H+/electron polar wind, for the hydrodynamic and semi-kinetic models. In general, we have found that there is significantly less tendency to form shocks and steep gradients in the semikinetic model than in the hydrodynamic model; owing to particle dispersion, such steep gradients tend to dissipate in the semikinetic description. We have also found increasing divergence between the two approaches generally as higher moments are considered; in particular, the parallel temperatures often deviate significantly. The general subject of hydrodynamic versus semi-kinetic modeling results is of significant interest currently, and we believe this work will be of substantial importance. It has been found, for the types of outflow situations considered, that the inclusion of heat flow has a major effect in bringing to closer agreement the parallel temperature profiles for the hydrodynamic and semikinetic models. A short paper on a slightly different aspect of the comparison will also appear in the proceedings of the MIT Geoplasmas workshop[Ho et al., 1993b].

Another interesting semikinetic study during this past six months concerns steady-state profiles of polar wind densities matched with the decade-old DE-1 total density profile of Persoon et al.[1983]. In this study, we used densities and drift velocities from low-altitude(2000-4000 km) polar wind observations of Chandler et al.[1991] as exobase O^+/H^+ parameter inputs for our semikinetic simulation. We found that if the combination of assumed base ion and electron temperatures is around 14000 K(e.g., T_e=9000 K, T_i=5000 K), the resulting polar wind steady-state density profile is dominated by O^+ to beyond 8 R_E, and that we obtain a virtually perfect match with the power law profile $n_e = 490r^{-3.85}cm^{-3}$ observed in electron densities by Persoon et al.[1983]. A paper[Ho and Horwitz, 1993] was submitted and accepted by *Geophysical Research Letters* during this period.

In one of the most exciting areas of progress, we have now developed a dynamic semikinetic model for examining the synergystic effects of waves and magnetospheric hot plasma populations on the outflowing ionospheric plasma. We have done this by imposing hot biMaxwellian ion and electron distributions at the top of our auroral simulation flux tube(4 R_e), as well as a spectrum of waves with altitude which perpendicularly heats the ionospheric ions. For example, when the hot ions are more strongly peaked at $\alpha = 90^o$ then the hot electrons, a positive potential develops at the top boundary, hence downward electric fields. With transverse wave heating below, this leads to a dynamic and partially self-consistent version of the "pressure cooker" concept proposed by Gorney et al.[1985]. This will forms part of the the Ph. D. dissertation of Mr. D. G. Brown, who passed his oral defense in May, and is now completing final correction of his thesis document.

The invited paper on plasma transport using semikinetic models[Horwitz et al., 1993a] for the Rarefied Gas Dynamics proceedings has been accepted and is in the process of being typeset for final publication.

We have also addressed the quasi-statistical properties of outflowing O+ through bulk parameter analysis of DE-1/RIMS observations when DE-1 was in the midaltitude polar cap magnetosphere. We have selected a technique which relies on analysis of the DE-1 radial head RPA data near the magnetic field direction for obtaining the O+ bulk parameters of density, temperature and flow velocity from these measurements. We have so far analyzed thirteen passes and tested our technique with reasonably good assurance in the derived parameters. Results were presented at the recent Baltimore AGU meeting[Ho et al., 1993c]. This work completes the basic research work for the Ph. D. dissertation of Mr. C. W. Ho, who is expected to complete his dissertation in September.

Other polar outflow-related papers presented at the Baltimore AGU meeting include an invited talk on Generalized SemiKinetic models[Horwitz et al., 1993b] and a GSK study of ExB driven outflows in the F-region/topside ionosphere [Wilson,1993]. In this latter study, all important collisional and chemical reaction terms were incorporated into a semikinetic model for field-aligned evolution of ion distributions in the 200-800 km altitude range. It was found that an outflux of O+ consistent with observations was seen in this semikinetic study that may have been inadequately described by a related generalized transport study by Korosmezey et al.[1992].

REFERENCES

Chandler, M. O., J. H. Waite, Jr., and T. E. Moore. Observations of polar ion outflows. *J. Geophys. Res.*, *96*, 1421, 1991.

Gorney, D. J., Y. T. Chiu, and D. R. Croley, Jr. Trapping of ion conics by downward electric fields. *J. Geophys. Res.*, *90*, 4205, 1985.

Ho, C. W. and J. L. Horwitz. Warm o+ polar wind and the de-1 polar cap electron density profile. *Geophys. Res. Lett.*, *in press*, , 1993.

Ho, C. W., J. L. Horwitz, M. Loranc, and T. E. Moore. Characterization of core o+ density, flow velocity and temperature in the 3-5 r_e polar cap. *Trans. Am. Geophsy. Un.*, *74*, 259, 1993c.

Ho, C. W., J. L. Horwitz, N. Singh, and G. R. Wilson. Plasma expansion and evolution of density perturbations in the polar wind: comparison of semikinetic and transport models. *J. Geophys. Res.*, *in press*, , 1993a.

Ho, C. W., J. L Horwitz, N. Singh, and G. R. Wilson. Comparison of hydrodynamic and semikinetic models in the study of time-evolution of density enhancement in the polar wind. 1993b. to appear in proceedings of MIT Geoplasmas conference.

Horwitz, J. L.,, G. R. Wilson, D. G. Brown, J. Lin, and C. W. Ho. Generalized SemiKinetic(GSK) models for space plasma transport. *eos*, *74*, 253, 1993b.

Horwitz, J. L., G. R. Wilson, J. Lin, D. G. Brown, and C. W. Ho. Plasma transport in the ionosphere-magnetosphere system using semikinetic models. *Proc. of Rarefied Gas Dynamics Conference*, *in press*, , 1993a.

Korosmezey, A., C. E. Rasmussen, T. I. Gombosi, and G. V. Khazanov. Anisotropic ion heating and parallel o+ acceleration in regions of rapid exb convection. *Geophys. Res. Lett.*, *19*, 2289, 1992.

Persoon, A. M., D. A. Gurnett, and S. D. Shawhan. Polar cap electron densities from de1 plasma wave observations. *J. Geophys. Res.*, *88*, 10123, 1983.

Wilson, G. R. The generation of o+ upflowing velocity distributions via exb convection in the transition region. *Trans. Am. Geophsy. Un.*, *74*, 253, 1993.